Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Declass Review by NIMA/DOD

STATINTL

[redacted]

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

[redacted] No. 7506 STATINTL

DIRECT IMAGE DIFFRACTION VIEWER - ENGINEERING AND DESIGN REPORT

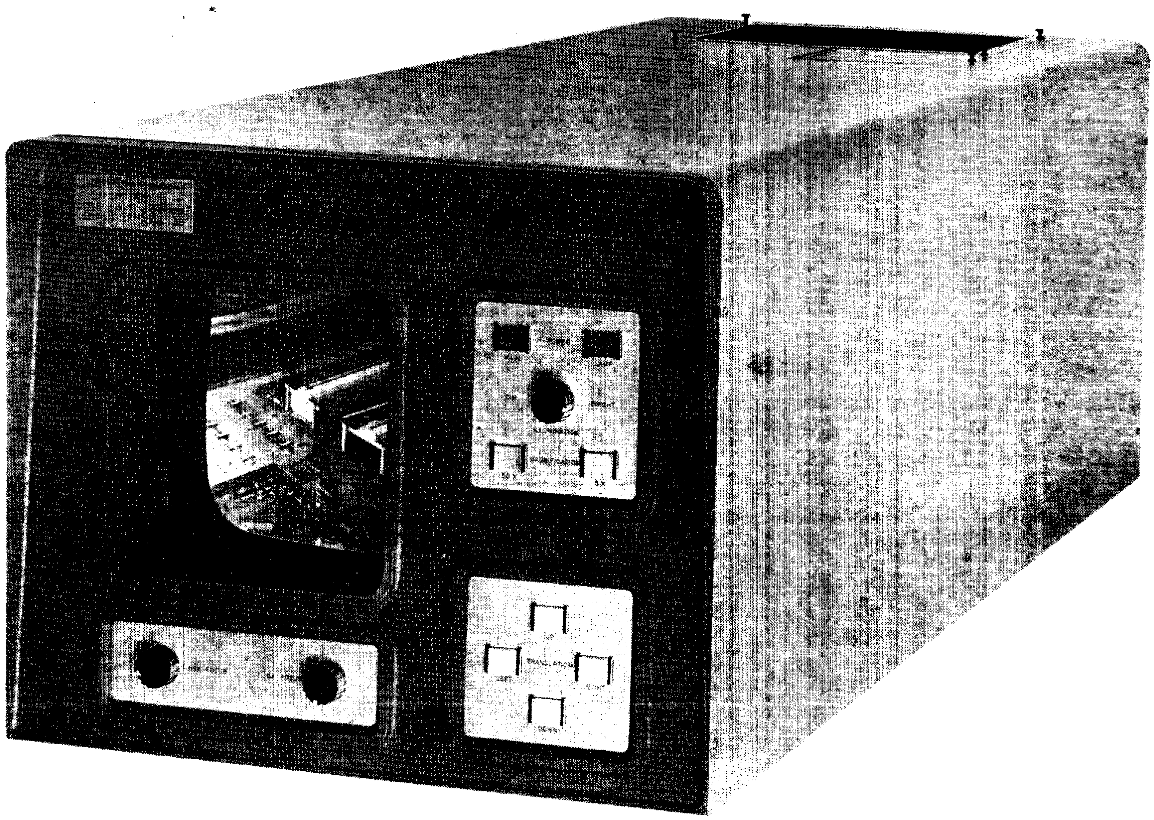
April 7, 1966

Contract Number [redacted] STATINTL

[redacted] STATINTL

Approved For Releas [redacted] 008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1



DIRECT IMAGE DIFFRACTION VIEWER

DUAL MAGNIFICATION 50X - 5X

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

TABLE OF CONTENTS

STATINTL

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

I. INTRODUCTION AND GENERAL COMMENTS

This document is a supplement to the viewer manual. That is, the manual describes the basic operating optical principles, specifications and operating procedures, whereas this document supplies technical backup data related to the more important engineering and design areas. The contents is a collection of technical data accumulated during the term of the project including results of tests performed on the viewer before delivery.

STATINTL

The technical information contained in this document originates at [redacted] Since phase reports were published by [redacted] and sub- STATINTL mitted directly to the customer, they have not been re-published in this document. Section V on diffraction gratings lists these

STATINTL

publications by [redacted] and the test results of the Trial 2 grating tested at [redacted] in the complete STATINTL viewer.

These two documents along with the viewer will allow the customer to fully evaluate the concept and generate ideas to future development of this unique viewing technique.

II. ELECTRO-MECHANICAL ENGINEERING DATA

A. <u>X-Y Translation Mechanism</u>

Considerable design effort was given to the film hold down and translation mechanism. The mechanism is required to hold two different film sizes by a vacuum and to translate in an X and Y plane over a total distance of 4 inches. The mechanism must also move in the X direction 8.865 inches to change magnification. This distance must always be moved no matter where the film chip is relative to the optical axis.

Two methods of approach were considered. The first involved two movement systems in the X direction. One of these would move the film 8.865 inches, the other would move the film ± 2 inches from a central position. Riding on this mechanism would be another carrier to move the film ± 2 inches in the Y direction. A second method was to use the same translating mechanism for both the X and magnification change. A clutch engaged counter system is then required to provide a sliding 8.865 movement. This latter system was selected.

STATINTL

[redacted] precision ball screw and nuts were selected as the drive members for the X and Y translation. Data was supplied by the manufacturer covering the expected life and load limits of the screw selected. The life of the ball screw with a 25 pound load is over 10^6 inches of travel. This exceeds the expected usage of the machine.

Another factor considered in the selection of components in this system was the slew rate for the film in X-Y mode and the time to change magnifications. Since only one speed is used to move in X-Y, and two different magnifications are used, the planned method of operation would affect the rate selected. After due consideration it was felt that 3 seconds/inch would be satisfactory. The rate at which the magnification is changed affects the repeatability of 8.865 movement as the faster rate makes it more difficult to stop quickly. Five seconds was selected as a reasonable time for the operation.

A schematic of the mechanism for X movement and magnification changing is shown in the following Drawing 7506-L8. The clutch is electrically engaged when the X movement is driven. Adjustment of the microswitches controls the 8.865 inch travel.

B. Lens Focusing

A mount was desired which would provide a smooth fine focus and be relatively inexpensive to fabricate. It was also

STATINTL

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Next 1 Page(s) In Document Exempt

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

desirable to have as much of the mechanism as possible under the table to be out of the way of the optical paths. The accompanying drawing 7506-L9 depicts the method selected.

This technique placed the actuating member beneath the lens. Also, the input shaft and worm drive may be rotated 360 degrees around the activated tapered shaft. This allows the same setup to be used for both lenses even though their optical axes are 90 degrees from one another.

The chain shaped mount that supports the lens is spring loaded against the tapered shaft. A reasonably linear movement relative to shaft rotation is obtained over ±0.050 range, the total range is ±0.062 for each lens. The angular rotational input from the knob is reduced 40 times through the 5X worm drive assembly and 120 times for 50X. The eccentric cam has a total radial displacement of 0.300 inch. This is reduced by a factor of 4 with the taper on the actuating shaft. A nylon tipped follower, which is used for coarse adjustment, follows the tapered shaft and drives the spring loaded "h" shaped lens mount. These reductions provide a lens movement of 0.002 inches for each revolution of the 50X focus knob and 0.006 inches for the 5X knob.

After testing, the only disadvantage noted was that the knob turned so freely, which caused a lack of "feel" that might be desirable, and which was later added via friction washers behind the control focus knobs.

III. OPTICAL DESIGN DATA

A. Overall Optical Plan

The overall optical configuration may be best utilized by examination of Drawing 7506-L5. This drawing shows the relationship of all optical elements and their respective distances apart.

STATINTL

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Earlier in the program consideration was given to designing an in-line system, but upon complete examination it was determined that changing magnification became more involved. The side by side approach is also easily adaptable to changing to other magnifications or adding a third position and magnification.

B. <u>Component and Sub-Assembly Data</u>

1. Multi-Element Field Lenses

The field lenses have two functions. They must first of all form a real image of the pupil of the imaging lens at a nominal distance of 20 inches from the field lenses and grating assembly. Moreover, the field lenses must be designed such that the light incident upon the grating is substantially parallel, and that adjacent diffracted pencils of light abut in the exit pupil plane.

The second requirement indicates that the part of the field lens assembly preceding the grating must have a front focal point located in the exit pupil of the imaging lens, and that it must be corrected for asymmetry errors in the sense that, for every point of the grating, the light arriving at the grating from the highest and lowest point of the aperture of the imaging lens includes equal but opposite angles with the axis of the system.

All these requirements can be met with a single element lens of the appropriate design.

The grating forms an array of abutting pupil images at infinity. The part of the field lens assembly following the grating must image this pupil array at a nominal distance of 20 inches. Two lens elements are adequate to achieve this. The field lens system is shown in Drawing 7506-L8. A generous space is left open between the two halves of the field lens for the grating.

STATINTL
Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

2. Objective Lenses

The 50X objective lens is a [redacted] Angenieux lens STATINTL of 1-inch focal length. The lens has been modified internally to contain a square aperture with an apparent side dimension of 0.707 inches. This square aperture is adjustable ±10% by means of an adjustment ring on the lens, and the square aperture does not rotate as its size is adjusted.

The 5X objective lens is a [redacted] lens of STATINTL 210-mm focal length. This lens has also been modified internally to contain a square aperture with an apparent side dimension of 0.707 inches with an adjustment range of ±10% by means of an adjustment ring on the lens.

3. Condensers

The following considerations determined the design of the condenser systems:

a. Both the film gate and objective lens aperture must be filled evenly with light.

b. The distance between the film plane and front of the condenser housing should be at least 0.540 inches for clearance of the film chip support mechanism.

c. Sufficient space must be allowed for a heat reflecting mirror, interference filter, and possibly a mildly ground glass. The areas to be filled with light and their distances are given below.

System	Film Gate Size	Lens Aperture	Distance Between
50X	.2 x .2 inches	.707 x .707 inches	1.1 inches
5X	2.0 x 2.0 inches	.707 x .707 inches	10.5 inches

d. A drawing of these assemblies is shown in Drawings 7506-L7 and 7506-L6.

STATINTL

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Next 1 Page(s) In Document Exempt

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

4. Field Flatteners

The single element preceding the grating in the field lens assembly causes a slight curvature of the image which must be compensated for in order to project a flat image onto the grating. This compensation is effected by placing a field flattener close to the object plane. The power of this lens is almost equal to the power of the single element in the field lens assembly, but it has the opposite sign.

A simple plano convex lens with a radius of 35 inches proves to be adequate. The diameter of this field flattener is only a small fraction of the diameter of the field lens element, which leads to quite shallow curves for the field flatteners. In particular the saggitus of the concave surface of the 50X field flattener does not exceed 0.0004 inches. In spite of this it is essential for the satisfactory operation of the equipment. This is due to the large aperture (f/1) of the imaging cone, and the large magnification of the imaging lens. The thicknesses of these field flatteners are 0.050 inches and 0.375 inches for the 50X and 5X system, respectively. The field flatteners are each located at 0.040 inches from the film plane.

5. Reflectors

By the use of a reflector a portion of the solid angle emitted by the lamp may be captured and reflected into the condenser system. By slightly displacing the image of the filament, the filament area may be made more even in brightness. The solid angle gathered by the reflectors need not be any larger than that which can be accepted by the condensers. With this in mind, reflectors with a clear aperture of 4.250 inches and a radius of curvature of 3.5 inches were used which encompass the solid angle of the condenser systems.

To eliminate some of the film heating problems, the reflector is coated with a heat transmitting coating, thereby transmitting the IR energy and reflecting the visible spectrum.

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

6. Filter Coatings

Three types of multi-layer interference coatings are used in the optics system. These are listed below:

a. The concave reflectors used behind the lamp have a coating designed to reflect light in the visible wavelength and to transmit longer wavelength radiation from the lamps. The transmission curve for this coating is given in Figure 1.

b. The condenser surfaces closest to the lamps and the surface of the 45 degree reflectors within the condenser assemblies have a coating designed to transmit the visible wavelengths and to reflect the longer wavelengths of infrared radiation. The first condenser surface coating is designed for normal incidence while the 45 degree reflector coating is designed for an incidence angle of 45 degrees. The transmission curve of these coatings is given in Figure 2.

c. The interference filters supplied with the condenser systems have a coating designed to transmit light at 5086 Å wavelength. The half-power bandwidth of these filters is 3%. The transmission curves of these filters is shown in Figure 3.

C. Modulation Transfer Function

The modulation transfer function depends mainly on the characteristics of the imaging lens and on the properties of the grating. The modulation transfer function of the lens in turn depends on the aperture that is being used. With the full aperture of F/1 the 50X imaging lens resolves well in excess of 700 l/mm. The 5X lens, used with an aperture of F/10 in the system, is essentially diffraction limited.

It is, however, [illegible] the matter of

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

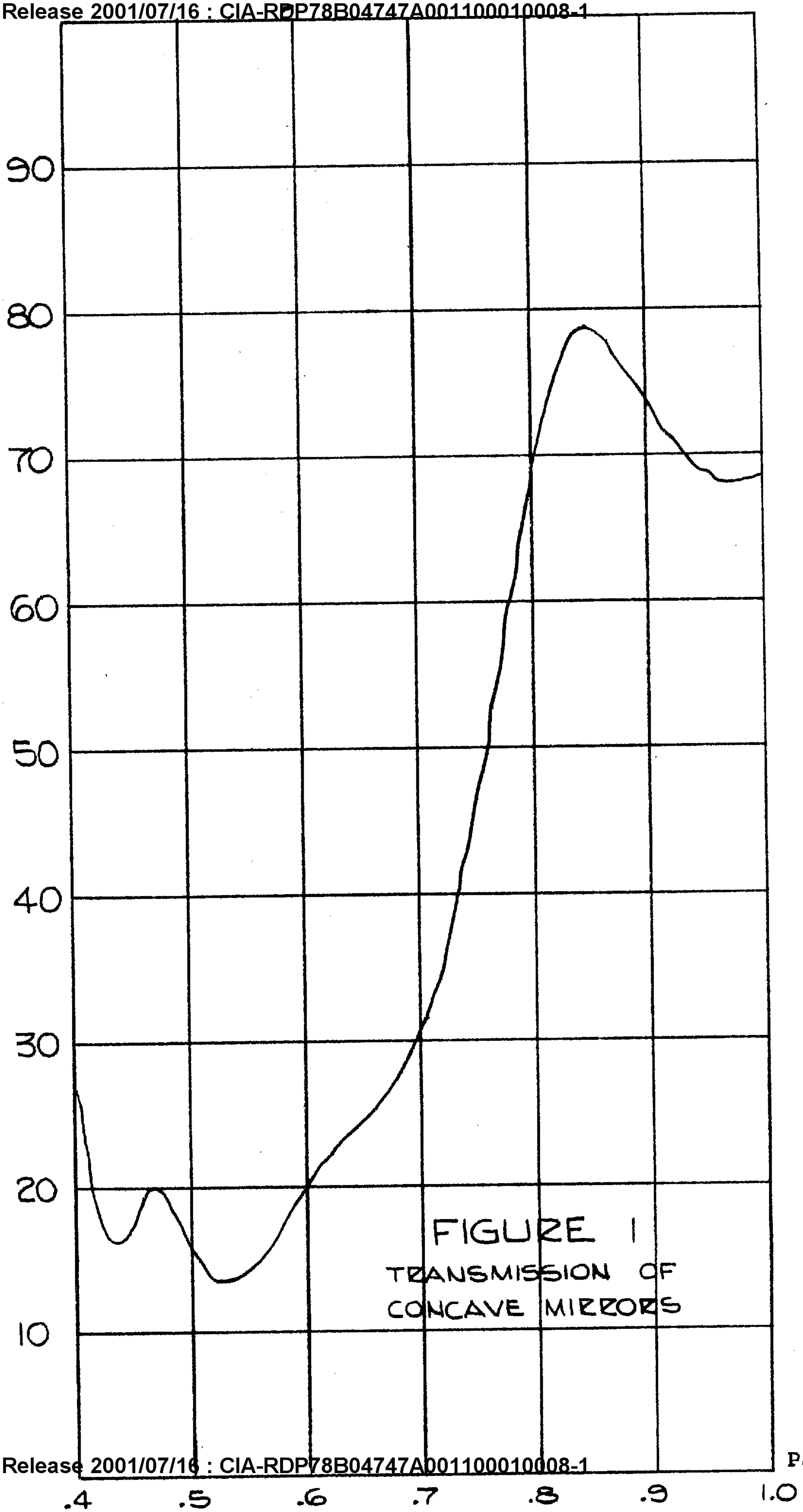


FIGURE 1
TRANSMISSION OF
CONCAVE MIRRORS

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

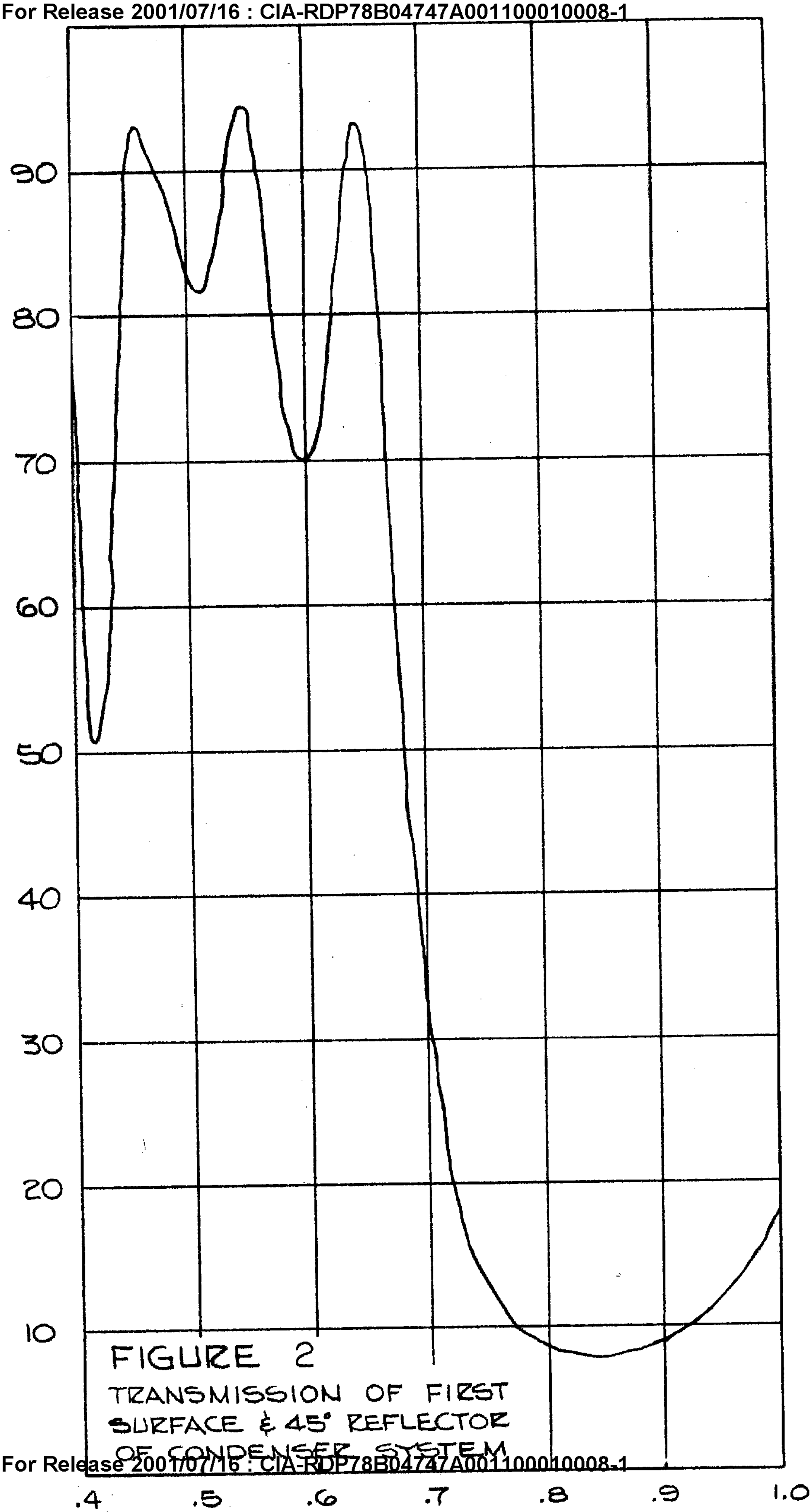


FIGURE 2
TRANSMISSION OF FIRST SURFACE & 45° REFLECTOR OF CONDENSER SYSTEM

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

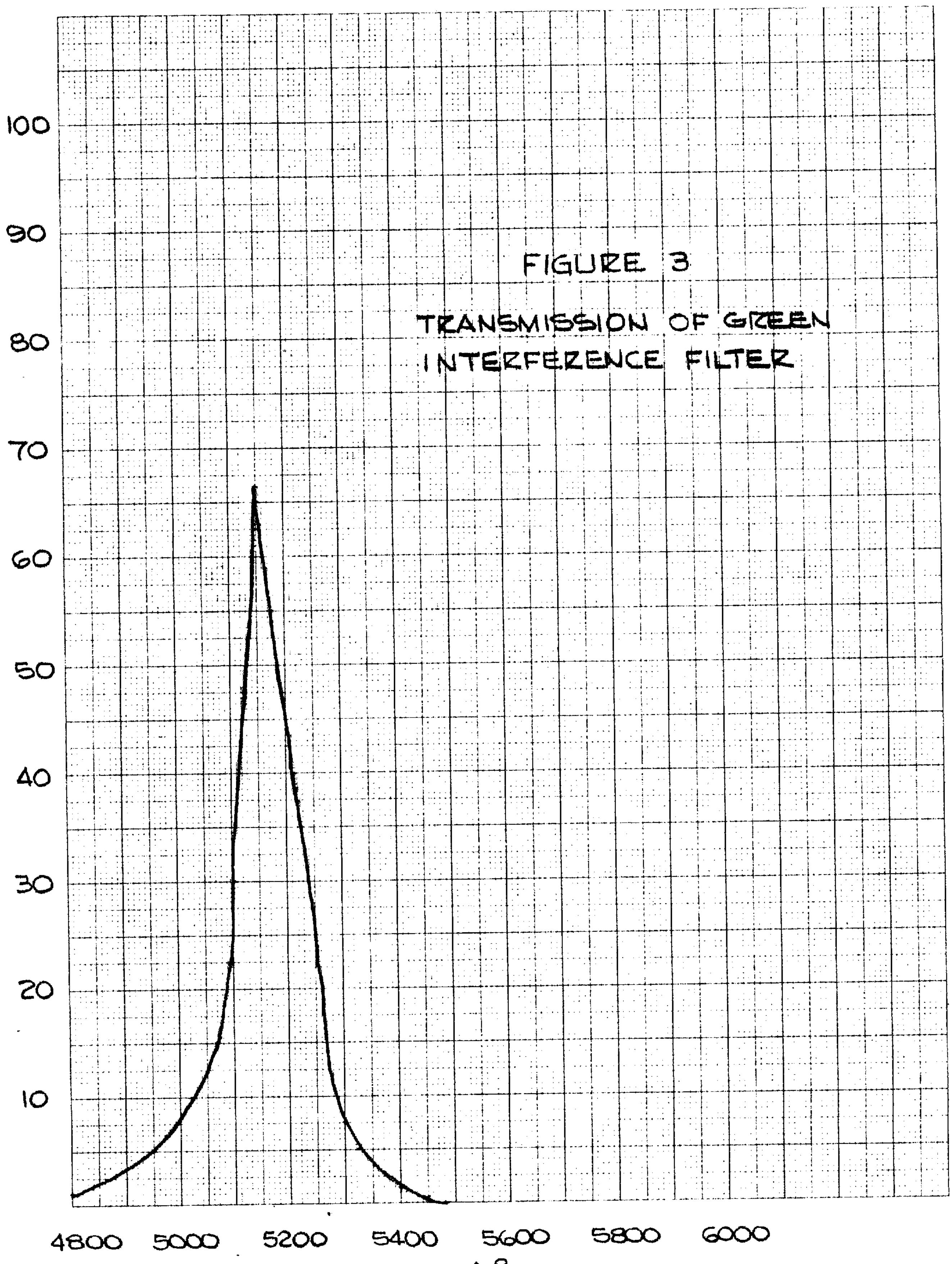


FIGURE 3
TRANSMISSION OF GREEN
INTERFERENCE FILTER
100
90
80
70
60
50
40
30
20
10
4800
5000
5200
5400
5600
5800
6000
Å

resolution without taking into account the properties of the observing eye. The eye does not resolve more than 5 l/mm at a distance of 20 inches. Projected back into the object plane this is equivalent to 250 l/mm in the film for the 50X system, and 25 l/mm in the film for the 5X channel. Consequently, the resolution of the system per se is much better than the resolution of the eye. Hence the modulation transfer function to be dealt with in practice is the modulation transfer function for the eye rather than for the instrument.

If, however, one uses the instrument not as it was meant to be used, and scrutinizes the image with a magnifying glass, then the estimation of the modulation transfer function is considerably more involved. The grating itself has a period of about 14 l/mm, which, projected back in the filmplane, represents 700 l/mm for the 50X system and 70 l/mm for the 5X system. For the 50X system this comes close to the limit of resolution of the lens; for the 5X system this is about a factor of 2 removed from its limiting resolution.

A fair discussion of the modulation transfer function under these circumstances is excessively difficult, due to the partial coherence in the grating plane. One approach, the validity of which is questionable, would be to assume that the grating has an averaging effect; i.e., that a light distribution I(x) arriving at the image plane is observed as:

$$I'(x) = \frac{1}{2\delta} \int_{-}^{+} I(x + \xi)\, d\xi$$

in which 2 is the line spacing in the grating. This would mean that the transfer function of the lens must be multiplied by

$$\frac{\sin 2\pi\nu\delta}{2\pi\nu\delta}$$

in which ν is the line frequency. This then leads to a cut-off frequency of 14 l/mm in the image.

Using this argument a crude estimate of the transfer function can be made. Possible curves are shown in Figure 4. If the transfer function is required with any accuracy we recommend that it be determined experimentally, especially because an estimate of the spatial phase shift is manifestly impossible.

IV. ILLUMINATION AND LIGHT SOURCE

A. Light Source Comparison Test

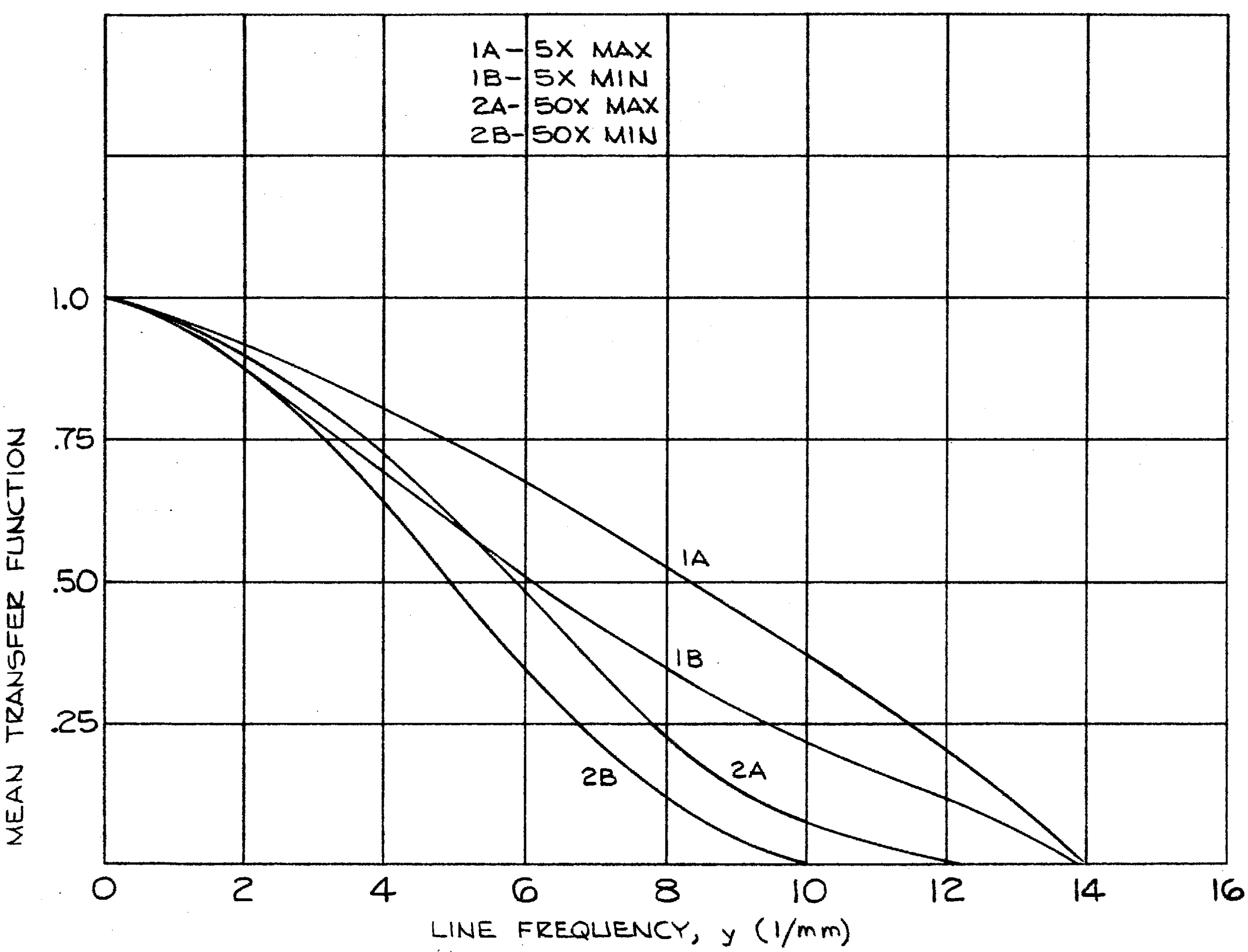
During the initial stages of the program, calculations were made to determine the light flux required. Calculations indicated that an 800 watt Xenon arc lamp would be sufficient.

STATINTL

Time was spent in discussing the engineering problems with [redacted] The results of this investigation indicated that the costs would be a substantially increase over that anticipated. This resulted in a submission for an increased scope. While this was progressing some thought was given to using a tungsten source. A graphical integration was made to obtain a rough estimate of the lumens available in the 5000 - 5200 Å portion of the spectrum. Results indicated that a 1500 watt projection bulb operating at 3200 - 3300°K. would have more useful flux than an 800 watt Xenon lamp.

The magnitude of the engineering effort to place the two sources into the viewer was compared and the tungsten projection lamp was found to have more advantages; the main one being in the area of intensity control. With the tungsten projection lamp this is accomplished by varying lamp voltage. The Xenon arc lamp conversely changes arc size and position when the current is varied; it therefore requires the insertion of a mechanical mechanism to vary the optical density of the light path. This along with the cooling and power supply problems placed strong incentive to switch to the tungsten projection bulb.

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1



Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

FIGURE 4
TRANSFER FUNCTION

STATINTL

With the cooperation of [redacted] tests were conducted which compared a 1500 watt projection lamp with an 800 watt and 1700 watt Xenon lamp. The 800 watt Xenon was a short arc type which is air-cooled; the 1700 watt had an arc two inches long and was water-cooled. The test consisted of measuring the light flux with a [redacted] photo resistor with peak sensitivity at 5100 Å covered by an interference filter with a band pass from 5000 to 5200 Å. Calibration was performed by placing neutral density filters over the detector and recording the cell current. STATINTL

The results indicated that the 1500 watt bulb had twice the output, in the direction normal to the filament, as the 800 Xenon short arc and 15% more than the tubular water-cooled 1700 watt Xenon.

By using a lens system the brightness was measured and, as expected, the Xenon short arc lamp was brighter than the projection bulb due to its small arc size.

Since the condenser could be designed for either source size, the total flux in a given direction was the important factor. Upon completion of these tests and a statement

STATINTL

from [redacted] indicating the condenser design could be changed, the change of scope proposal submitted was retracted and the 1500 watt bulb incorporated into the viewer design.

B. <u>Illumination Calculations</u>

1) Light Flux Required

By specification the viewer is required to present to the operator at least that amount of light flux as presented by a lambertian source with a luminance of 100 ft-lamberts.

Since the viewer images the light on an exit pupil rather than diffusing or directing it over a very large solid angle, the amount of flux required to pass through the field lens is much less than with a diffusion screen.

Assuming a lambertian diffusing screen, the light flux may be calculated that falls into a 3.5 x 3.5 inch area, which is the total exit pupil matrix of concern. Then if the gratings directed all light into this area, this is the light flux that would be required to pass through the final field lens element.

The following calculations perform this conversion. A luminance of 100 foot lamberts equal 343 lumens/m^2. The grating size is 10 x 10 inches and is located 20 inches from the 3.5 x 3.5-inch exit pupil matrix. By calculation of the solid angle involved, it is found that 0.68 lumen are contained in the exit pupil.

$$\frac{343 \text{ lumen}}{m^2} \times \frac{(10 \text{ in})^2 \times (3.5 \text{ in})^2}{(20 \text{ in})^2} \frac{(0.0254 \text{ meter})^2}{\text{inch}^2} = .68 \text{ lumen}$$

2) Light Flux Available with 1500 Watt Tungsten Projection Bulb

Given: Operating temperature - 3300°K
Bandwidth 5100 - 5250 Å

And using $\dfrac{\int_0^\lambda \omega \, d\lambda}{\int_0^\infty \omega \, d\lambda}$

the radiance emittance ratio (RER)

can be found. By subtracting RER for 5100 Å from that obtained at 5250 Å a value of 0.006672 is obtained.

Then 1500 watts x 0.006672 = 10 watts of power from 5100 - 5250 Å. To convert this to lumens the relative visibility factor (RVF) is used as well as the 680 lumens/watt as peak eye sensitivity.

Then 10 x 0.4 (RVF) x 680 = 2720 lumens. Calculations then proceed assuming that 1400 lumens radiated from each side of the bulb filament in a Lambertian manner.

b. Optical Train Calculations - 50X system

The solid angle from the condenser and reflector were considered along with the reflectance and transmission of the optics. Of the 2700 lumens, 415 would enter the condenser system.

The small size of the film becomes a field stop even though the bulb filament is imaged at or near the film plane. The solid angles of the condenser output to the film cannot match that between the film and objective lens. For these reasons some light is lost.

Calculations indicated that 9.35 lumens would leave the objective lens. The effective illuminance at the film plane would be 40 lumen/cm^2.

A 25% efficiency was assumed for the grating along with 86% for the field lens. This would place 1.9 lumens in the exit pupil plane. This is about three times the amount required.

c. Optical Train Calculations - 5X System

The solid angles were again determined. With the larger diameter condenser in the 5X system it was found that 525 lumens would enter the condenser system.

In the 5X case the bulb filament is imaged at the objective lens. With the optical system used, the filament image is larger than the lens clear aperture; therefore, some light flux is lost. Additional light is lost at the film gate as the light bundle is larger than the 2 x 2-inch viewing area.

The results of this indicated that 43 lumens would go through the objective lens with a film plane illuminance of 2.1 lumens/cm^2.

Using the same field lens and grating efficiencies as in the 50X case there would be 8.2 lumens in the exit pupil plane.

The calculations then indicated that at 5X there would be four times more flux than at 50X in the exit

d. Conclusions

The calculations indicated that sufficient light flux would be available at the exit pupil plane to meet the specifications. Actually the specifications were low; that is, if possible, more flux should be made available. If additional brightness is not required by operating the bulbs at full voltage, their life will be substantially increased by a slight voltage reduction.

As indicated previously, the effective lumens are a function of filter bandwidth. Calculations were made with a 150 Å band pass. This is very narrow, about 3%, and by increasing to 5% or 6%, with the increase toward longer wavelengths, the total lumens will be more than doubled.

V. DIFFRACTION GRATING

A. Publications

1) The requirements of the grating are listed in the work statement provided for [redacted] and the viewer specifications. STATINTL

a. Statement of work for [redacted] STATINTL
25 August 1954 [redacted] No. 7506.03 STATINTL

b. Direct Image Viewer specifications.
25 August 1964 Project 7506
Contract [redacted] STATINTL

STATINTL

2) The results of efforts by [redacted] have been reported at the completion of each phase of effort. These reports have been passed on to the customer. The documents are listed below.

a. Diffraction gratings for direct image viewer. Report on Phase I submitted October 24, 1964.

b. Diffraction gratings for direct image viewer. Final report Phase II, Trial 1, submitted January 29, 1965.

c. Diffraction gratings for direct image viewer.

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

STATINTL

Final report Phase II, Trial 2, submitted May 25, 1965.

B. Exit Pupil Measurement with [redacted] Trial 2, Phase II

1) Test Conducted

The two 2-inch-square replicas were crossed, placed emulsion to emulsion and inserted into the center of the field lens. A calibrated photo resistor was used to measure the light falling on the gratings and the variations in the exit pupil plane. The sensitive area of the detector was less than the .142 x .142 exit pupil element. This .142 x .142 area is created by a 50% overlap in the x and y axis of the .284 exit pupil.

Measurements were made to determine three values.

a) The % of energy falling in the exit pupil area compared to that falling on the grating.

b) The total illuminance difference between exit pupil elements.

c) The greatest adjacent illuminance differences.

2) Results

a) Over 35% of the energy passing through the first grating is contained within the 3.5x 3.5-inch-square exit pupil.

b) The maximum illuminance difference was from near or at the center of the exit pupil matrix to one of the cross-over points, when the low 9th and 10th orders overlapped. This difference was 3.7:1 which is less than the 4:1 required.

c) The greatest adjacent illuminance difference was near one of the cross-over points. The 1.75 ratio measured was under the 2:1 required.

The grating performed very satisfactorily and exceeded the specifications. The results indicated that the technique is adequate for fabrication of the 200 [illegible]

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

C. Exit Pupil Measurements of Final Grating

1) Test Conducted

The test conducted was similar to that used on the two-inch-square gratings discussed in the foregoing section with similar measurements being made.

2) Results

It was expected that the results would be as before because the same ruling was used. The measured results reported below bear this out. The visual effect is quite different though. The amount of forward and backward head movement was reduced by the larger gratings. Even though the exit pupil variations were alike the sensitivity of the system to head movement was increased. The reason for this seems to be the aperture change of the field lens. With the two-inch gratings, the exit pupil was larger than the grating or aperture of the system. Whereas with the 10-inch gratings, the reverse is true, with the aperture (gratings) being 3 times the size of the exit pupil. The image forming light cone in the exit pupil plane went from F/7 to F/1.4. Because of this, the exit pupil focus range is reduced which causes a more severe change in the light pattern as the head is moved out of the exit pupil plane of focus.

a) The maximum illuminance difference was from the four outside corners (brightest) to the cross-over of the 9th and 10th orders (darkest). This difference was 2.5:1 which is less than the 3.7:1 measured with the 2-inch gratings and the 4:1 specified.

b) The greatest adjacent illuminance difference was 1.6:1 which is less than the 1.7:1 measured with the 2-inch gratings and the 2:1 required.

VI. DATA FROM TESTING FINAL CONFIGURATION

A. Resolution Comparison of Direct Image Viewing (Diffraction Gratings) to Rear Projection Diffusion Screen

The field lens and grating were removed and replaced with a sheet of [redacted] fine grain diffusion sheet.

STATINTL

Approved For Release 2001/0[redacted]4747A001100010008-1

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Mil Spec 150A resolution targets were used to read resolution. The targets used had two contrasts, 1000:1 and 1.6:1, both having clear bars on a dark background. The same targets were then used after the field lens and grating were installed. Comparative data is given below:

	On Axis		Average Four Corners	
50X Magnification	High Contrast	Low Contrast	High Contrast	Low Contrast
Direct Image Viewing (Diffraction Gratings)	228	216	155	95
Diffusion Screen	228	75	86	42

The viewer was focused to give optimum resolution at each area, but with both horizontal and vertical bars resolvable to the level indicated at the same focus setting.

B. Light Flux Measurement

Before any light flux measurements can be made, a calibrated probe is required. Since a narrow spectral band is used, the sensing device must have the spectral sensitivity of the eye if lumens are to be read directly. A calibrated measuring system of this type was not available. It was then decided to calibrate a green sensitive photo resistor. The accuracy of this in-house set-up was sufficient for demonstrating compliance with the 100-foot lambert luminance requirement.

In Section 4.B (1) a conversion is made from the 100-foot lamberts to .68 lumen in the exit pupil. Knowing the area of exit pupil and the conversion from lumens to watts for the wavelengths involved, microwatts per square centimeter can be determined. The required value becomes 32 μwatts/cm^2. Calculations were made to determine the number of watts/steradian emitted in the wavelengths of interest from the 1500 watt bulb. In section 4.B (2) calculations are given which show that 10 watts of power exist in the 5100 - 5250 band used. For purposes of calculation, it was conservatively assumed that the power was evenly emitted over

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

10 steradians. This would be 1 watt/steradian. The following calculation was made to find at what distance a watt density of 32 μwatts/cm would exist.

$$\text{Steradian} = \frac{A}{R^2} \qquad \text{For 1 steradian } R^2 = A$$

$$R = \sqrt{A} \qquad \text{then } \frac{1 \text{ watt/steradian}}{32\mu \frac{\text{watt}}{CM^2}} = CM^2$$

Area of 1 watt/steradian at specified level.

Then $R = \sqrt{A} = 70$ inches.

A green filter from the viewer was placed over a photoresistor held 70 inches away from the filmant surface of the bulb and a resistance reading taken. Known neutral density filters were added to obtain values below the 32 μwatt/cm^2 level. To obtain values above this level, known neutral density filters were placed over the photoresistor-filter combination and it was moved closer to the source until the same reading was received as was obtained without the filter at the 70-inch position. The neutral density filters were then removed and a reading made. This reading indicates a value above the reference level equal to the neutral density filter. A chart was made using this technique with the basic calibration point at 32 μwatt/cm^2 level which is required at the exit pupil.

The probe was then placed in the exit pupil plane of the viewer while at 50X and 5X with an open film gate. Since there is a 2.5:1 brightness difference over the exit pupil area, an average illuminance area was measured and the values shown below:

	μwatts/cm^2	Lumen (Total exit pupil)	Apparent Image Brightness Ft-Lamberts
Required value	32	.68	100
Expected value 5X	385	8.2	1200
Expected value 50X	89.5	1.9	280
Actual value 5X	149	3.2	470
Actual value 50X	47	1.0	147

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1

Measurements indicated that the brightness ratio between the 50X and 5X systems were similar but slightly closer together than that calculated. The actual values are greater than that required but less than that calculated. Wider band interference filters can be used to increase the brightness per watt and therefore allow operating the lamps at lower voltage levels.

The initial calculations were required to assure that the lamp chosen would meet the viewer specifications. The final measurements are then used to show compliance and verify the calculations. For a system as involved as this, with an unknown loss of the gratings, it was felt the agreement of measurements to calculations was satisfactory.

Approved For Release 2001/07/16 : CIA-RDP78B04747A001100010008-1